# Infrared Analysis of LMC Superbubbles

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We are analyzing three superbubbles in the LMC, those cataloged by Meaburn (1980) as LMC-1, LMC-4 (a.k.a. Shapley Constellation III), and LMC-5. Superbubbles are the largest infrared sources in the disks of external galaxies. Their expansion requires multiple supernovae from successive generations of star formation. In LMC superbubbles, the grains swept up by shocks and winds represent an ISM whose abundances are quite different from the Galaxy. By applying the Dwek (1986) grain model, we can derive the composition and size spectrum of the grains. The inputs to this model are the dust emission in the four IRAS bands and the interstellar radiation field (ISRF) that provides the heating.

The first step in our project is to derive the ISRF for star-forming regions on the periphery of superbubbles. We are doing this by combining observations at several wavelengths to determine the energy budget of the region (see the flowchart).
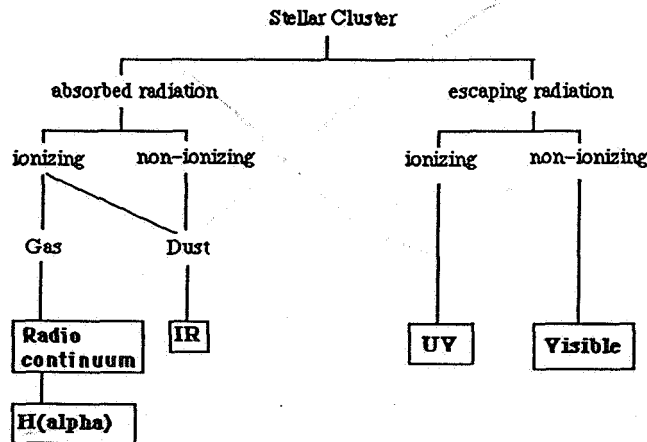
We will use a UV image to trace the ionizing stellar radiation that escapes (Smith, Cornett, and Hill 1987), an Hα image to trace the ionizing stellar radiation that is absorbed by gas (Kennicutt and Hodge 1986), and the four IRAS images to trace the stellar radiation, both ionizing and non-ionizing, that is absorbed by dust. This multi-wavelength approach has the advantages that we do not have to assume the shape of the IMF or the extinction of the source.

We have only just begun this project, so for now we present some preliminary results on the superbubble LMC-1. IRAS coadds, shown below, provide a resolution of 1' or 15 pc. This bubble has a roughly triangular shell of diffuse emission, with one strong infrared peak associated with the HII region DEM 34 (Davies Elliott, and Meaburn 1980).

LMC-1.100
LMC-1.60
LMC-1.25
LMC-1.12

DECLINATION

RIGHT ASCENSION
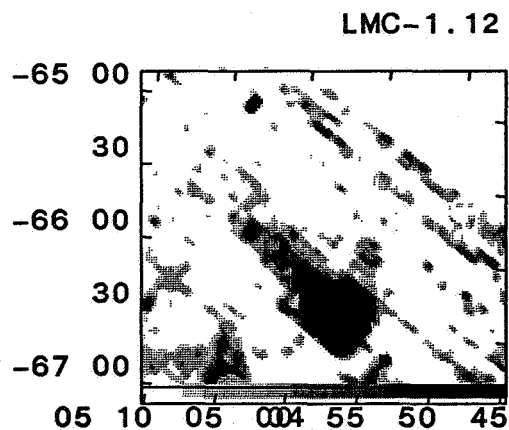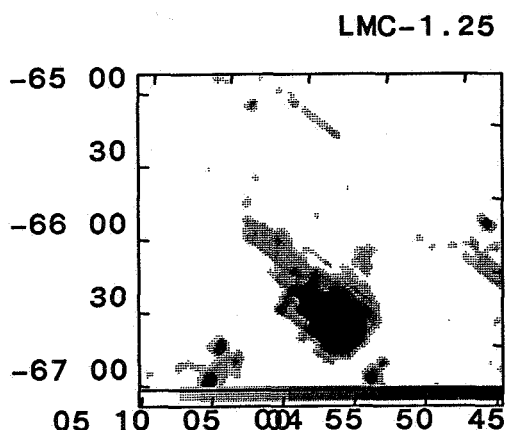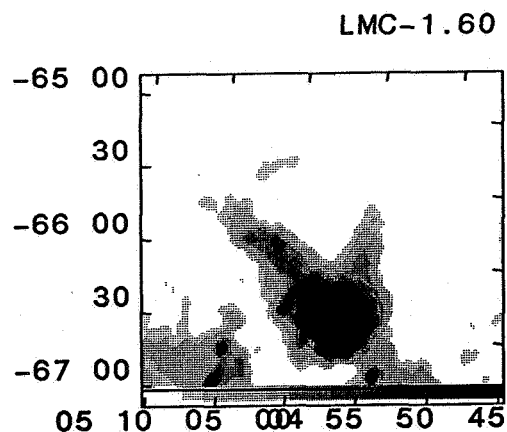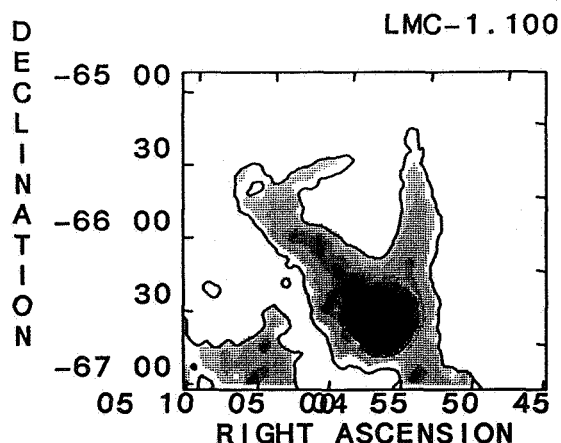
The diffuse emission of LMC-1 is not detectable at 12 and 25 μm. We modeled the grain content of the northernmost leg of the diffuse shell by assuming the ISRF of the local Galaxy, and taking into account the known differences in the LMC grain abundances: The dust/gas ratio is 4 times lower than in the Galaxy (Koornneef 1982), and the graphite/silicate ratio is 3 times lower than in the Galaxy (Nandy 1984). In order to fit the observed spectrum, the grain size distribution must be cut off below 30 to 100 Å. By comparison, Galactic clouds are usually modeled with grain distributions containing graphite particles down to 3 Å size (Verter 1989).

From our grain model and the LMC dust/gas ratio, we find that the total mass of the cloud corresponding to this leg of the diffuse emission is 1.6×10^6 M$_\odot$. This cloud was mapped in CO emission by Cohen et al. (1987). The standard Galactic conversion from CO emisison to molecular hydrogen mass would have calculated the cloud mass to be 2.0×10^5 , an order of magnitude underestimate.

The peak emission of LMC-1 at DEM 34 shows clear evidence for destruction of very small grains. This is best seen in plots of the flux ratios $I(60\mu m)/I(100\mu m)$ and $I(25\mu m)/I(12\mu m)$ along a slice through the peak.
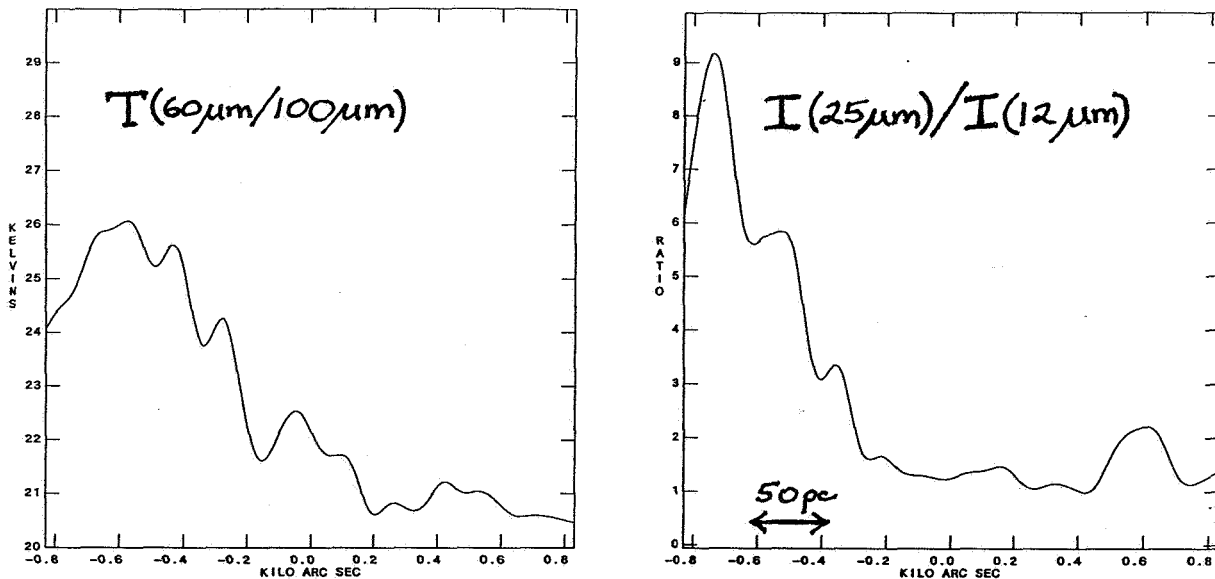
The increase in $I(60\mu m)/I(100\mu m)$ towards the luminosity peak indicates that the big ($>$ 200 Å) grains are hotter in the vicinity of DEM 34. The contribution to $I(25\mu m)/I(12\mu m)$ from stochastically heated very small ($<$ 200 Å) grains is near unity for all small grain temperatures. Thus the increase in this ratio is driven by increasing contributions to $I(25\mu m)$ from big grains. But the temperature of the big grains in this vicinity, derived from $I(60\mu m)/I(100\mu m)$, is at most 30 K. Under such heating, $I(25\mu m)/I(12\mu m)$ should be only 1.1 (see Figure 4 of Boulanger et al. 1988). The factor of 9 increase in $I(25\mu m)/I(12\mu m)$ that is seen implies that the big grains are dominating the ratio because the very small grains are being destroyed in the vicinity of DEM 34.

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